CHAPTER 3
AIRWORTHINESS STANDARDS
TRANSPORT CATEGORY ROTORCRAFT

MISCELLANEOUS GUIDANCE (MG)

AC 29 MG 7. STRUCTURAL CONDITION INDICATORS.

a. Related Sections. § 29.301 - Loads; § 29.305 - Strength and Deformation; § 29.571 - Fatigue Evaluation of Flight Structure; § 29.1301 - Function and Installation; § 29.1309 - Equipment, Systems and Installations; § 29.1321 - Arrangement and Visibility; § 29.1322 - Warning, Caution, and Advisory Lights; § 29.1355 - Distribution System; § 29.1503 - Airspeed Limitations: General; and § 29.1529 - Instructions for Continued Airworthiness.

b. Background.

(1) Structural condition indicators have been used on rotorcraft for several years in two main programs: as part of the basic type design and as part of airworthiness directive (AD) action. When approved as part of the basic type design, only limited “credit” has been given for the installation of structural condition indicators; i.e., components provided with a structural condition indication system were required to be designed to § 29.571 “safe-life” criteria considering the structural condition indicator system inoperative. So-called “nonhazard” approvals were granted. When used as part of the mandatory actions of ADs, structural condition indicators have had a degree of “credit” recognized, primarily in the recognition of “fail-safety” provided by the indicator system.

(2) Since structural condition indicators have been used during both original type design and AD issuance, and since there is movement toward increased damage tolerance in rotorcraft design, policy concerning condition indicator use is considered appropriate.

c. At present, the use of structural condition indicators alone on new type designs is not considered an acceptable substitute for providing the necessary safe life for each component. However, areas which may be considered when approving these indicators for fail-safety credit are delineated in the following paragraphs.

d. What, how, when, where, and who of structural condition indicators.

(1) Indication of what?

(i) Previous structural condition indicators have primarily been used for crack detection. Several types of through-the-thickness crack detection systems are currently in use. Two types which detect changes in pressure in an instrumented chamber due to gas movement through a cracked wall are known as the blade inspection method (BIM) system and the integral spar inspection system (ISIS). These systems can only detect full-depth cracks which are large enough to allow loss (of gain) of pressure from the instrumented chamber. This presents a limitation since full-depth cracks may be fast growing before detection. Another through-the-thickness crack method is a pressurized, dyed fluid or oil system to detect through cracks in specially designed bolts (NASA patent), spindles, pins, or other closed chamber mechanical equipment.

(ii) Surface cracks can be found by systems such as surface-mounted crack detection wires. These systems would allow a greater safe crack growth period for assuring safe landing after detection than the through-crack-detection systems, but they have been used little in operations because of significant limitations; e.g., complexity of installation, durability problems, limited areas of coverage, and strain level limitations.

(iii) Some aircraft have had mast moment indicators or other load indicators to help prevent the pilot from inadvertently applying a high load to the instrumented system or to help the pilot reduce the load by control movements. These load indicators only indirectly give indications of structural condition; therefore, only limited "credit" is allowed for this use. "Credit" is limited in that the fatigue life substantiations of § 29.571 should consider a reasonable number of excursions into the higher ranges established for the load indicator, and special inspections, rework, or replacement instructions should be provided for any strength degradation associated with high range excursions.

(2) How indicated?

(i) Current BIM systems use two types of indicators. The visual blade inspection method (VBIM) uses a gauge mounted on the blade which must be read visually by maintenance personnel while the aircraft is parked. The cockpit blade inspection method (CBIM) uses lights mounted in the cockpit which may be monitored by the crew. Other pressurized chambers have used dyes or oils to improve visual inspection effectiveness. Mast moment indicators and other load indicators use instruments with marked ranges and needles.

(ii) No specific types of load indicators are required by the FAA/AUTHORITY but the type used should be evaluated for accuracy, readability, and overall effectiveness. Paragraphs AC 29 MG 7(e) and (f) cover, in more detail, the use of structural condition indicators.

(3) When indicated? Structural condition indicators are used before flight, during flight, and for normal maintenance inspections. Paragraphs AC 29 MG 7 (e) and (f) contain guidance for cockpit-mounted instruments which are monitored during flight. Indicators used for normal maintenance inspections are the preferred type since they can be scheduled to allow the most effective use of available maintenance personnel of well-equipped maintenance facilities and of parts available.

(4) Where indicated? Indications on the component are provided by VBIM systems and by systems utilizing dye or colored oil leakage. Cockpit-mounted lights and gauges may be used for certain critical structures which require frequent, but simple, checks. Maintenance panel locations (cabin, equipment bay, etc.) are the preferred locations for use in routine maintenance.

(5) Who reads indicators? The flightcrew, of necessity, monitors indicators mounted in the cockpit for use during flight. Gauges with ranges of values representing mast bending moments or other structural loads are monitored by the flightcrew, as necessary, to reduce or to prevent control operations from imposing excessive loads or to prevent too many high load applications. Maintenance personnel are generally responsible for reading component-mounted indicators and for monitoring indicators which are mounted on maintenance panels. The before-flight checks may be conducted by maintenance personnel or by flightcrew in certain cases (i.e., cockpit-mounted gauges or “push-to-test” checks).

e. Actions required by indicators.

(1) On-ground indications. Indications noted on the ground should be followed by a functional check of the indication system as provided for by its design. If indications persist after the system has been checked and found to be functional, further inspection of the affected component(s) should be conducted for damage assessment. Any damage found as a result of the detailed inspections should be repaired or replaced as appropriate.

(2) In-flight indications.

(i) Indications used for in-flight monitoring have in the past been used for two main reasons: to provide a structural load display (such as mast bending moment) and to help resolve a service problem (CBIM systems have been used to supplement conventional inspection methods in blind areas).

(ii) Structural load display systems should not be used instead of correcting deficient designs. Structural load display systems are appropriate for use in locating control positions, such as the cyclic stick, under transient conditions such as slope landings and hover in sidewinds, but structural load display systems are not considered appropriate for routine operations such as climbout or cruise with constant attention required by the flightcrew. If the load indicator provides a needed tool to the pilot in limited types of operations and does not significantly add to pilot workload otherwise, its use can be considered.

(iii) In the past, certain service problems have been solved by adding in-flight indicators such as CBIM systems. When retrofit of the affected structure is impossible or impractical, and when conventional inspection techniques are shown to be inadequate by themselves, CBIM or similar systems may be the only practical solution, despite the increase in pilot workload and the potential for problems caused by overreaction by the pilot to a structural fault indication. When used for correction of service difficulties, the structural condition indicator system should be accompanied by clear, concise crew directions to prevent possible catastrophic overreaction. Load reduction measures such as rotor speed changes, airspeed reductions, altitude changes, etc., should be clearly provided, if needed. Crack propagation time from indication should be sufficient to allow continued safe flight to a safe landing area. For new designs, CBIM or similar systems which add to the pilot's workload are considered inappropriate. Proper redesign to provide the needed safe life, fail-safety, and inspectability is considered the appropriate action.

f. Complementary considerations of structural condition indicator use.

(1) Two basic programs are commonly used for approval of structural condition indicators. Basic type certification procedures are used for mast moment indicators and similar systems, and AD's (with appropriate type design changes) are used for CBIM systems which require pilot attention and corrective action when an indication of a structural fault is detected.

(2) The fatigue substantiation required by §§ 27.571 and 29.571 should consider a conservative number of excursions into the high load range monitored by a structural condition indicator such as a mast moment indicator. Static strength should not be adversely affected by a single excursion into the high load range monitored by the indicator.

(3) Complementary design provisions should accompany the use of a structural condition indicator system. Redundancy of load paths and inspection systems and indicator system failure analyses should be provided, as necessary, to meet the requirements of § 29.1309. The life remaining after the indicator system detects a structural failure should be calculated (with test verification), and compatible inspection and/or overhaul programs should be provided.

(4) The FAA/AUTHORITY approval of a structural condition indicator system requires evaluation by the airframe, systems and equipment, and flight test specialists. The airframe specialist has the responsibility to review effects of structural condition indicator system use on aircraft loads, strength and deformation, and structural fatigue evaluation as well as the instructions for continued airworthiness. The systems and equipment specialist needs to evaluate the system for function and installation as well as the reliability requirements of § 29.1309. Flight test evaluation of the instruments' arrangement and visibility, effect on crew workload, and possible changes for RFM is also needed. Care should be exercised to assure that responsibilities are not given to the flightcrew which would be more appropriately handled by a redesign or by the maintenance personnel. Early coordination between all specialists is necessary to prevent delays from last minute design changes.